

C.I.P.S.

MODELE MATHEMATIQUE DE LA  
POLLUTION\_EN\_MER\_DU\_NORD

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Towards a simulation model for the Copepods zooplankton spring growth in the Sluice Dock at Ostend .

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As in a previous report on the modelling of the phytoplankton spring bloom , this model attempts to provide a framework based on observational grounds and theoretical assumptions. As such ,it remains open to further adjustments . It is designed for interconnection with the phytoplankton model .

Copepods have been shown to take a prominent part in the zooplankton of the Sluice Dock . DARO (1974) has studied the topic extensively . Also VANDENDAELE (1972) and PALMER (1975) have contributed to the knowledge of zooplankton dynamics in the Sluice Dock. According to DARO , overwintering eggs generate a population of nauplii (=first development stage) that develops from the beginning of April . The maximum recorded is  $240000 \text{ indiv./m}^3$  . A copepodites population (next important development stage) follows one week later . The maximum recorded is 20000 to 100000  $\text{indiv./m}^3$  . And finally, adults have their maximum about one week later (up to  $40000 \text{ indiv./m}^3$  ). A second generation of nauplii develops from the end of May (max = 120000 to 100000  $\text{indiv./m}^3$  ) etc .

Our interpretation of these observed data in terms of generation time , growth rate and mortality rate is however

different as we assume that the population(numbers) of a given development stage is at any time the resultant of :

input from the previous stage  
minus output to the next stage  
minus mortality

the actual specific growth in the various stages governing the input and the output rates . Therefrom less signification is to be attributed to peaks height and apparition time .

All this originates from the fact that eggs are not hatching on the same day but on a period of about two months (first generation) .

Our simulation model assumes that  $n$  classes are generated on a period of  $n$  days ( as a matter of simplification) , presumably with an optimal sub-period , hence the sine function of time :

$$N_t = x + ( x \cdot ( \sin \frac{2\pi(t - t_0 - \frac{n}{4})}{n} ) )$$

where  $N_t$  = number hatched at time  $t$

$x$  = 1/2 of maximum hatched/day in period

Each class  $N_i$  is allowed to grow in biomass until the ratio  $B_i / N_i$  is such that the class passes into another category , governed by another growth equation (switch function) .

For a given class  $N_i$  :

$$\frac{d B_i}{dt} = ( k - m ) B_i$$

and  $k = C1 \cdot I_{\max} ( 1 - e^{-d(P-P')} )$  (Ivlev-Parsons)

$m = C2/k + C3$  (Mommaerts , cf phytopl. model )

where  $I_{\max}$  = maximal ingestion/unit zooplankton biomass

$d$  = constant

$P$  and  $P'$  = actual phytoplankton biomass and threshold concentration

$C1$  = conversion to net production constant

$k$  = net zooplankton production

m = mortality . In the absence of demonstrated predation, we consider a natural mortality inversely proportional to growth rate (taken as health index) + a statistical mortality (hence constants C2 and C3 ) .

Where the total biomass of a given development stage is concerned, one cannot calculate general input, growth and output constants since the age distribution within the stage is not stable and since the feeding conditions are changing all the time as a result of the grazing by all stages . Therefrom numerical integration and switch functions are needed :

$$\frac{d B}{d t} = \frac{\sum dB_{input}}{dt} + \frac{\sum dB_i}{dt} - \frac{\sum dB_{output}}{dt}$$

Figs. 1A and 1B show the simulations of respectively numbers and biomass variations for the three stages of the first generation in a much simplified case (growth always maximal and no mortality at all but for the final output from the adult stage) .

The further steps would take 1°) zooplankton mortality into account and 2°) the dual aspect of the zooplankton-phytoplankton interaction a) grazing mortality

$$m_{phyto} = \sum I B_i \text{ of all stages}$$

b) enhancement of primary production by excretory products

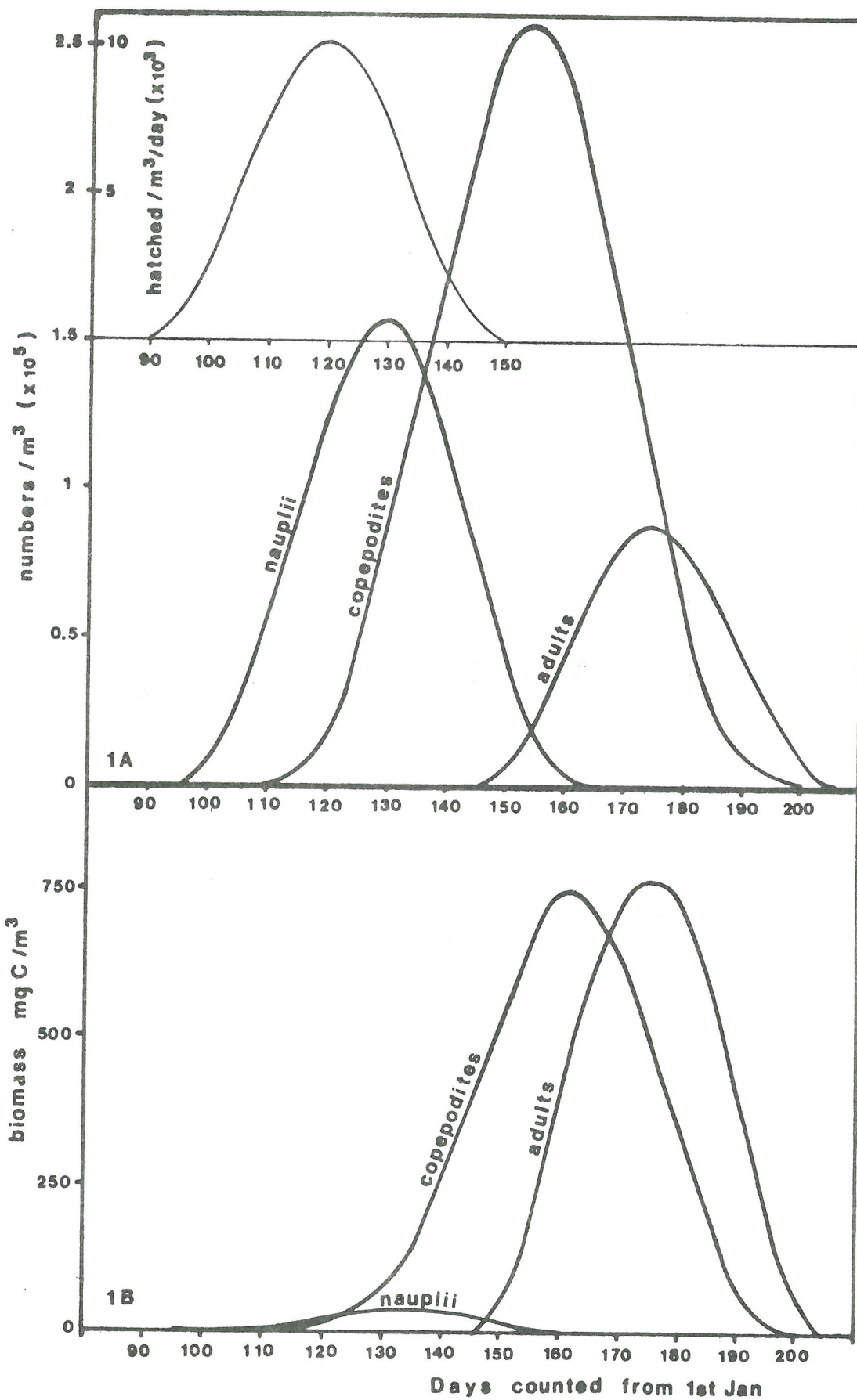
$$+ \frac{dN}{dt} = \sum e B_i \quad (e = \text{excreted fraction of Ingestion})$$

$$\text{so that } k_{phyto} + \frac{dk_{ph}}{dt} = \frac{k_{max} + (N + \frac{dN}{dt})}{K_s \cdot (N + \frac{dN}{dt})}$$

3°) Assay of nocturnal or continuous grazing

4°) Simulation of the second generation :

C4 . N<sub>i</sub> adult females produce C5 fertile eggs/indiv. that become nauplii with a time lag C6 .



Constants and initial values used in the simplified simulation

$X = 5000 \text{ /m}^3\text{/day}$   
 $C1 = .15$  (net production = 15 % of ingested matter)  
 $I_{\text{max nauplii}} = .060$  mg C/mg C animal /hour  
 $I_{\text{max copepodites}} = .048$  " " "  
 $I_{\text{max adults}} = .020$  " " "  
Initial biomass of a nauplius =  $8 \cdot 10^{-5}$  mg C  
" " copepodite =  $48 \cdot 10^{-5}$  mg C  
" " adult =  $736 \cdot 10^{-5}$  mg C  
Final biomass of an adult =  $1008 \cdot 10^{-5}$  mg C